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Site conditions in infrastructure development

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INTRODUCTION

Either through discriminatory zoning regulations or through the influence of market forces of demand for the limited urban space or as a phenomenon of pure chance, low-income urban settlements are to be found located on sites that would otherwise be described as 'difficult' for housing development. The terrain is either too rugged and steep or it is too flat and swampy for effective drainage; the soils may also depict very poor engineering performance characteristics. Also since the development of infrastructural services often takes place within an already haphazardly built-up area, the settlement pattern also presents its constraints that have to be contended with. The institutional and administrative bottlenecks need no mention here (Ref. 1).

Kitui, Kanuku, and Kinyago villages are typical examples of unplanned low-income settlements to be found in Nairobi, Kenya. The paper looks at how site conditions have affected the development of sanitation infrastructure services in the above villages, and in particular the problem of disposing of increasing volume of sullage - the liquid component of domestic waste water. The paper proposes a model aimed at handling the disposal of sullage in the study area and in other isolated settlements in tropical countries with similar site conditions and constraints.

Background

The present settlement form of Kitui, Kanuku and Kinyago villages started in 1983 after a fire destroyed former cardboard and plastic paper house structure units on June 12, 1983. Undugu Society of Kenya (a Non-governmental organisation), together with the local community, has been in the forefront in assisting improved development of the villages.

With a present population of 5000 people and an average household size of 5 persons with a monthly average income of Ksh.500, the study area is located about 3 kilometres from Nairobi CBD, downstream along Nairobi river. The settlement is spread along the immediate valley slopes draining into the river and also along the floodplain.

SITE CONDITIONS

As mentioned above, the study area is located on the immediate slopes overlooking Nairobi river. The ground rises from 1628 metres to 1636 metres above sea level with an average ground slope of 1 in 9. Part of settlement is however located within the river floodplain. The soils are predominantly black cotton soil underlain by Kerichwa valley tuffs and the floodplain soil is a mixture of alluvial clay soils.

A site inspection indicates that the area suffers from frequent floods that often wash away the built house structures. The flooding problem is made worse due to the sluggish river flow caused by vegetative growth and dumped solid waste in the river. The river is heavily polluted as it passes through the city. In the dry period, for example, the natural flow in the river is so low that the river is virtually an open sewer for the dissolved oxygen content is barely more than 0.5 milligrams per litre and is often nil (Ref. 2).

Rainfall figures in Nairobi give an annual average of 900mm with two main rain seasons in March-May (long rains) and the short rains of October-December. Heavy thunderstorms are not uncommon and result in local floods. The average temperature varies between 17 and 20 degrees centigrade, although temperatures can be as low as 4 degrees centigrade and as high as 33 degrees centigrade.

SITE CONSTRAINTS

What constraints do the above site conditions present to the provision and development of sanitation infrastructure? After assisting the local community in the construction of the house structure units, Undugu Society now faces the task of extending services to the study area. Having utilized all the land on the valley slopes for the construction of residential units, the only open area remaining is along the river floodplain.

Efforts to build pit-latrines along the flood plain have not been fruitful. With unstable alluvial soils and a watertable within 1 metre, the pit-latrines are barely 2.5 metres deep. Due to unstable conditions,

the walls of the pit often collapse and cave in. The situation is made worse by the floods that wash everything away.

Having extended communal water points into the study area, the residents now face a more serious environmental problem caused by the waste water generated (Ref. 3). The problem is particularly acute in respect to sullage - the liquid component of domestic waste water - that is found everywhere around the residential units. The residents cannot connect to the city trunk sewer nearby because the line is located on the upper grounds relative to the settlement area, and the connection fees is too high. It is estimated that a connection fees of over Kshs. 1,000,000 is needed for 6 such connections. How will the local community solve the problem of disposing of the increasing volume of sullage?

PROPOSED MODEL

One major constraint to the implementation of civil engineering infrastructure programmes among the unplanned low-income urban settlements is the high cost of development (Ref. 4). This is also made more difficult by the inappropriateness of many conventional technologies in use today and their environmental sustainability limitation in respect to socio-economic and site conditions.

Considering the socio-economic and site conditions of the study area, the paper has proposed a model to handle the disposal of sullage produced in the area (Ref. 5). The model proposes the following developments along Nairobi river flood plain that is presently under-utilized:-

1. The development of a sand-filter bed zone into which the small bore sewer system discharges sullage effluent produced in the villages (Figure 1);

2. The development of a graded eucalyptus tree zone or a similar tree species with a high rate of transpiration and waater-uptake and able to withstand water-logged conditions(Ref.2); and

3. The training of the river by deepening and lining the river channel to allow more effective water flow in the river to minimise the flood problem and lower the water-table (Figure 3).

Figure 1 shows a sand-filter trench that receives sullage and treats the waste as it percolates through the sand media. This system is ideal for site conditions where the water-table is within 1 metre of the ground surface (Ref. 6). It is estimated that the quality of the effluent from the sand filter media is safe enough as to be discharged into the surface water point like Nairobi river (Ref. 7). In order to enhance the loading capacity of the sand-filter media, a eucalyptus tree zone is proposed (Ref. 8). The eucalyptus will improve the uptake of water from the likely water logged soils along the floodplain, besides improving the porosity of the alluvial soil and consequently the infiltration of water through the sand-filter media. The nutrients in the effluent will greatly enhance and support the rapid growth of the eucalpytus.

CONCLUSION

It is envisaged that the proposed model will offer the following benefits, if proven successive:

1. The enhancement and protection of the urban environment, minimising costs of treating waste effluent, and maximise the utility of otherwise abused and idle land along the river.

2. The model should appeal to many isolated settlements that may not be served by central trunk sewer lines and many other smaller concentrated settlements in dry regions within the tropics.

It is important to note that the proposed model has yet to be tested. The aim of presenting it in the conference is therefore to receive a critique and comments as to its viability so as to improve it before it is actually tested and applied. It is the anticipation of the authors that the comments and support received from the conference will go along way to advancing the search for more effective technologies to support development among the poor in developing countries.

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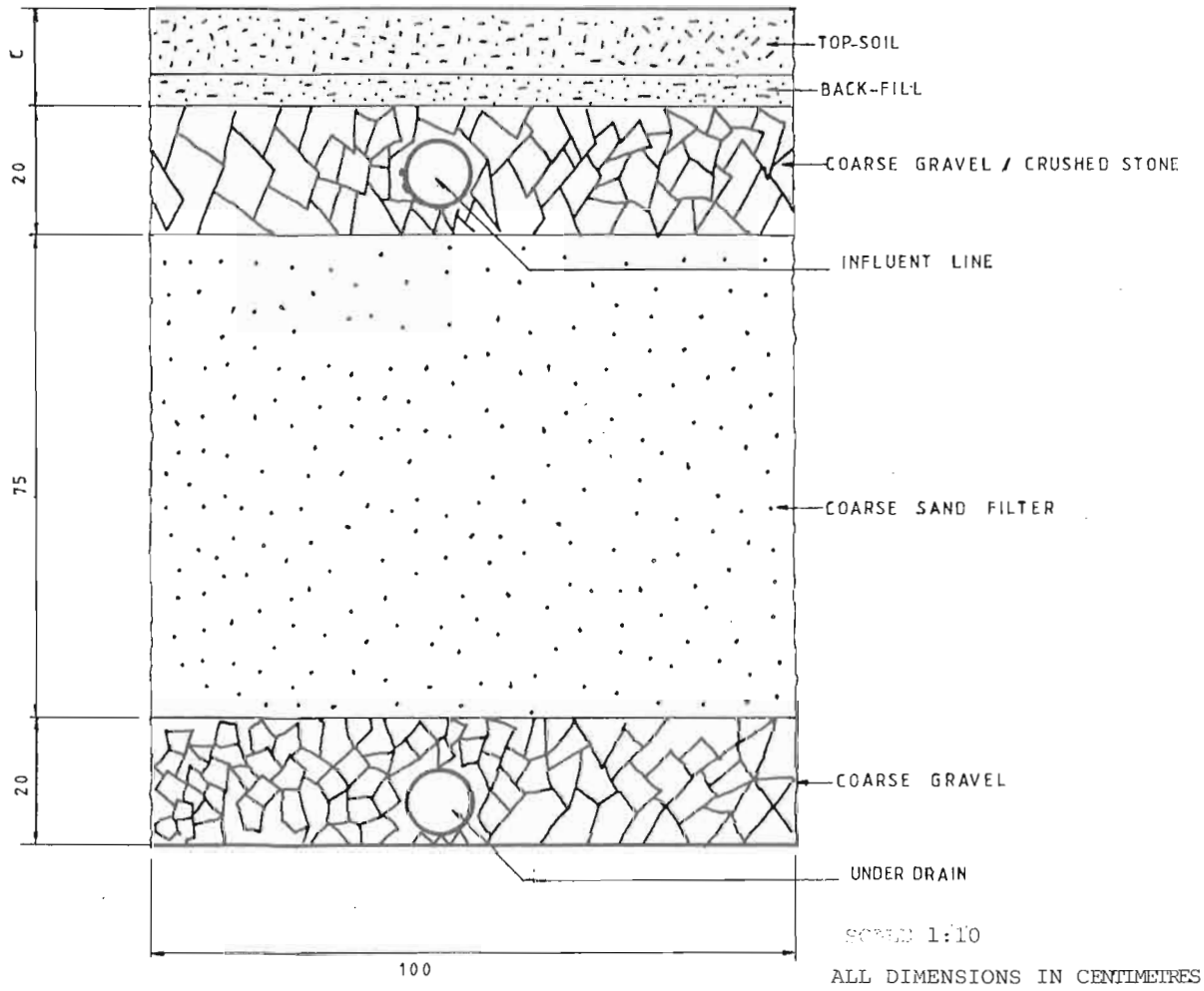
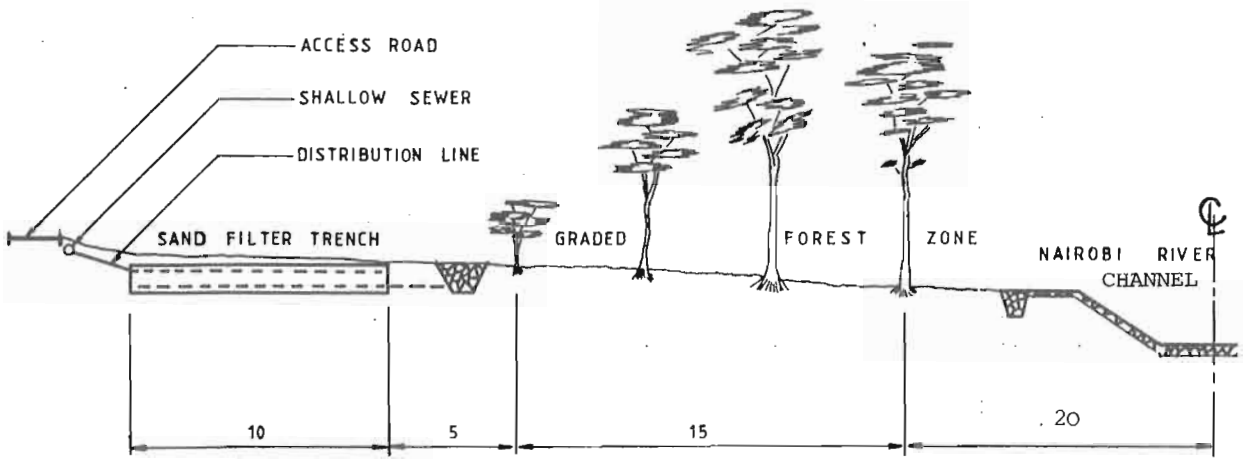


FIGURE 1
A SECTION THROUGH SAND-FILTER TRENCH

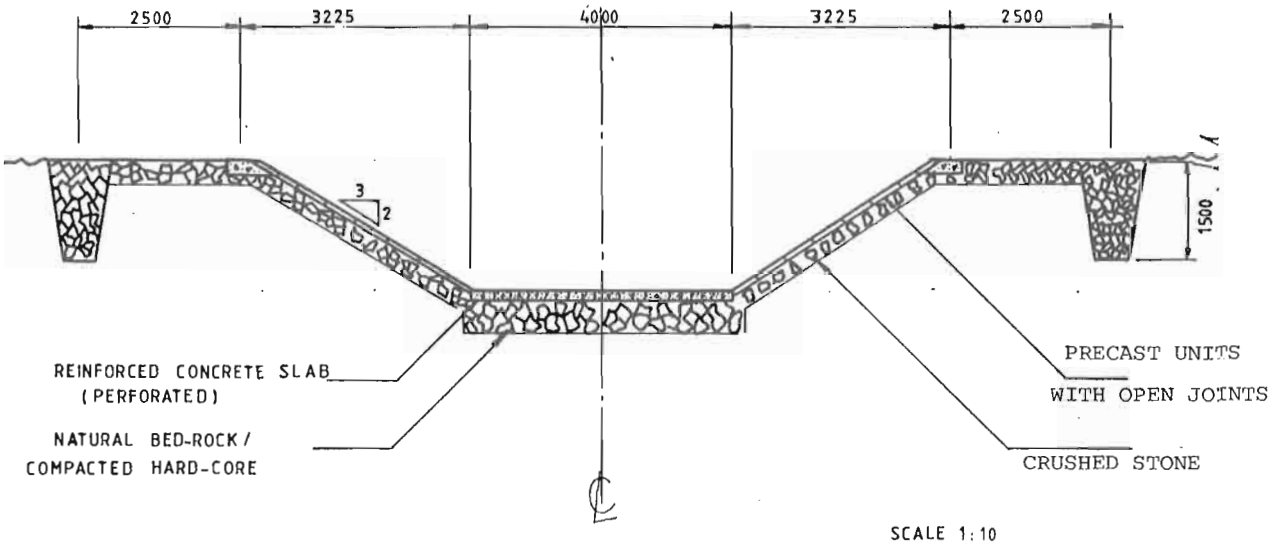


SCALE 1:250

ALL DIMENSIONS IN METRES

FIGURE 2

PROPOSED WASTEWATER DISPOSAL SYSTEM AND RIVER DEVELOPMENT



SCALE 1:10

ALL DIMENSION IN MILLIMETRES

FIGURE 3

PROPOSED RIVER CHANNEL